The listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

- 1. (currently amended) A method of obtaining magnetic resonance signals with signal separation for at least two chemical species in a heterogeneous magnetic field <u>using rapid</u> gradient echo imaging, comprising the steps of:
- a) obtaining first magnetic resonance signals from pixels in an object having at least two chemical species using a first repetition time and a first echo time,
- b) obtaining at least second and third magnetic resonant signals from the pixels using second and third echo times,
- c) determining a signal estimate <u>for each species and</u> for each pixel by combining all signals for the pixel using a linear least squares fitting <u>of the signals from each pixel</u> to decompose the chemical species, assuming a first value of field heterogeneity (ψ_0) ,
 - d) calculating a first error to the field heterogeneity,
 - e) repeating step c) using the first value of field heterogeneity and the error from step d),
 - f) repeating step d) to calculate a second error to the field heterogeneity, and
- g) updating the value of field heterogeneity and repeating steps c) and d) until an acceptable error is calculated.
- 2. (original) The method as defined by claim 1 wherein M chemical species are present and step b) includes obtaining at least M+1 magnetic resonance signals for each pixel.
- 3. (original) The method as defined by claim1 wherein fat and water are two chemical species and step b) includes obtaining three magnetic resonance signals.
- 4. (original) The method as defined by claim 1 wherein in step b) the magnetic resonance signals at time, n=1 to N, for species, j=1 to M, having real, R, and imaginary, I, parts is given by:

$$\hat{s}_{n} = \hat{s}_{n}^{R} + i\hat{s}_{n}^{I} = \sum_{j=1}^{M} (\rho_{j}^{R} c_{jn} - \rho_{j}^{I} d_{jn}) + i \sum_{j=1}^{M} (\rho_{j}^{R} d_{jn} + \rho_{j}^{I} c_{jn})$$

and a least squares fitting of all signals is given by:

$$\hat{\boldsymbol{\rho}} = (\mathbf{A}^T \mathbf{A})^{-1} \mathbf{A}^T \hat{\mathbf{S}}$$

where A is a known matrix for M species.

5. (original) The method as defined by claim 4 wherein:

$$\mathbf{A} = \begin{bmatrix} c_{11} & -d_{11} & c_{21} & -d_{21} & \dots & c_{M1} & -d_{M1} \\ c_{12} & -d_{12} & c_{22} & -d_{22} & \dots & c_{M2} & -d_{M2} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ c_{1N} & -d_{1N} & c_{2N} & -d_{2N} & \dots & c_{MN} & -d_{MN} \\ d_{11} & c_{11} & d_{21} & c_{21} & \dots & d_{M1} & c_{M1} \\ d_{12} & c_{12} & d_{22} & c_{22} & \dots & d_{M2} & c_{M2} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ d_{1N} & c_{1N} & d_{2N} & c_{2N} & \dots & d_{MN} & c_{MN} \end{bmatrix}$$

where $c_n^{fw} = \cos(2\pi\Delta f_{fw}t_n)$, $d_n^{fw} = \sin(2\pi\Delta f_{fw}t_n)$, $g_n^R = 2\pi t_n \left(-\hat{\rho}_w^I - \hat{\rho}_f^R d_n - \hat{\rho}_f^I c_n\right)$ and $g_n^I = 2\pi t_n \left(\hat{\rho}_w^R + \hat{\rho}_f^R c_n - \hat{\rho}_f^I d_n\right)$ are the matrix elements.

6. (original) The method as defined by claim 4 wherein error to the field heterogeneity is given by:

$$\mathbf{y} = (\mathbf{B}^T \mathbf{B})^{-1} \mathbf{B}^T \hat{\hat{\mathbf{S}}}$$

where B is a matrix given by:

$$\mathbf{B} = \begin{bmatrix} g_{11}^R & c_{11} & -d_{11} & c_{21} & -d_{21} & \dots & c_{M1} & -d_{M1} \\ g_{12}^R & c_{12} & -d_{12} & c_{22} & -d_{22} & \dots & c_{M2} & -d_{M2} \\ \dots & \dots \\ g_{1N}^R & c_{1N} & -d_{1N} & c_{2N} & -d_{2N} & \dots & c_{MN} & -d_{MN} \\ g_{11}^I & d_{11} & c_{11} & d_{21} & c_{21} & \dots & d_{M1} & c_{M1} \\ g_{12}^I & d_{12} & c_{12} & d_{22} & c_{22} & \dots & d_{M2} & c_{M2} \\ \dots & \dots \\ g_{1N}^I & d_{1N} & c_{1N} & d_{2N} & c_{2N} & \dots & d_{MN} & c_{MN} \end{bmatrix}$$

where

$$\mathbf{y} = \begin{bmatrix} \Delta \psi & \Delta \rho_1^R & \Delta \rho_1^I & \Delta \rho_2^R & \Delta \rho_2^I & \dots & \Delta \rho_M^R & \Delta \rho_M^I \end{bmatrix}^T, \ g_{jn}^R = 2\pi t_n \sum_{j=1}^M \left(-\hat{\rho}_j^R d_{jn} - \hat{\rho}_j^I c_{jn} \right) \text{ and}$$

$$g_{jn}^I = 2\pi t_n \sum_{j=1}^M \left(\hat{\rho}_j^R c_{jn} - \hat{\rho}_j^I d_{jn} \right).$$

7. (original) The method as defined by claim 6 wherein step a) includes obtaining signals from a single coil.

- 8. (original) The method as defined by claim 6 wherein step a) includes obtaining signals from a plurality of coils and steps b) through g) are performed for signals from each coil, and further including the step of:
 - h) combining field heterogeneity as determined from signals for each coil.
- 9. (original) The method as defined by claim 8 wherein field heterogeneity is determined by weighting contributions from each coil.
- 10. (original) The method as defined by claim 9 wherein the weighting contribution from each coil is a function of the square of the magnitude of the image contributed by that coil.
- 11. (original) The method as defined by claim 10 where for each pixel, at position r, the combined field map is:

$$\psi_c(\mathbf{r}) = \frac{\sum_{p=1}^{P} \psi_p(\mathbf{r}) |s_p|^2}{\sum_{p=1}^{P} |s_p|^2}$$

where P coils collect P independent images.

- 12. (original) The method as defined by claim 11 wherein the combined field heterogeneity from step h) is smoothed by passing through a low pass filter.
- 13. (original) The method as defined by claim 11 wherein M images of each species are obtained using signals from each of M coils and the combined field heterogeneity, and then combining the M images using a square root of the sum of the squares of the images.
- 14. (original) The method as defined by claim 1 wherein step a) includes obtaining signals from a plurality of coils and steps b) through g) are performed for signals from each coil, and further including the step of:
 - h) combining field heterogeneity as determined from signals for each coil.
- 15. (original) The method as defined by claim 14 wherein field heterogeneity is determined by weighting contributions from each coil.

- 16. (original) The method as defined by claim 15 wherein the weighting contribution from each coil is a function of the square of the magnitude of the image contributed by that coil.
- 17. (original) The method as defined by claim 16 where for each pixel, at position r, the combined field map is:

$$\psi_c(\mathbf{r}) = \frac{\sum_{p=1}^{P} \psi_p(\mathbf{r}) |s_p|^2}{\sum_{p=1}^{P} |s_p|^2}$$

where P coils collect P independent images.

- 18. (original) The method as defined by claim 17 wherein the combined field heterogeneity from step h) is smoothed by passing through a low pass filter.
- 19. (original) The method as defined by claim 17 wherein M images of each species is obtained using signals from each of M coils and the combined field heterogeneity, and then combining the M images using a square root of the sum of the squares of the images.